TITLE: Switching Bistable Leech Heart Interneurons with a Pulse of Current from Bursting to Silence

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Leech heart interneurons (HNs) control the heartbeat of the medicinal leech. They are organized in mutually inhibitory pairs, half-center oscillators (HCOs). Biophysically accurate models of HCO and HN exhibit bistability of bursting and silence. A pulse of current can switch the HN between coexisting regimes. Characteristics of a pulse switching a neuron from silence to bursting has been previously investigated in this model; however, pulses that switch bursting to silence have not been characterized. Knowledge of the properties of switching pulses are essential for revealing bistability in the living HNs. It could be also useful for the development of effective biofeedback systems controlling heart pacemakers.

Outcomes of applying pulses with duration of 30 msec were analyzed. Depending on the amplitude and phase of the pulse, the outcome can be a switch from bursting to silence or no switch. Pulse characteristics were tested by methodically studying responses of a model to single pulses with different amplitudes chosen from [-0.5nA to 0.5nA] delivered at different phases ranging from 0% to 100%. Each set of amplitude and phase values were plotted on a map and the 2 possible outcomes were color coded. The same method was applied to both the single HN and the HCO models.

The single HN map indicated that either hyperpolarizing or depolarizing perturbations could switch the bursting regime to silence. In the single HN, 20.84% of the total perturbations switched the activity from bursting to silence. Surprisingly, the HCO model allowed 0.0% switching. Perturbations delivered to each cell in the HCO simultaneously also allowed a total of 0.0% switching.

We conclude that the HCO is effective in protecting the dynamics of the functional regime of activity against 100% of studied external perturbations in neurons exhibiting bistability. Also, we identified the sets of pulse properties which trigger a switch in a single HN. These sets will be used for experimental testing of these neurons for bistability. The results of this study can aid the development of biofeedback technology controlling pathological regimes or driving proper rhythm of hearts experiencing cardiac fibrillation.